Why microtools must be so precise

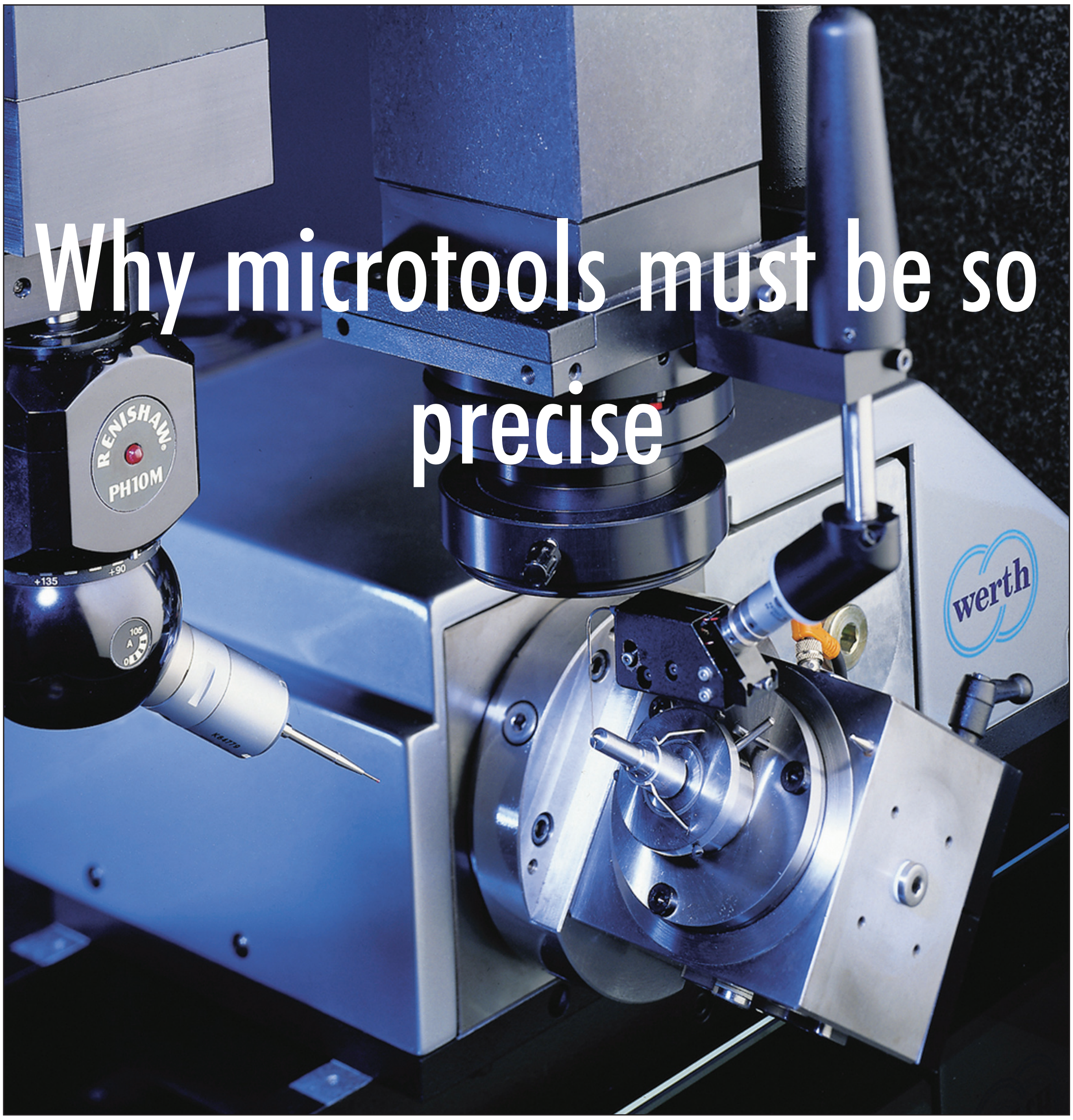

Figure 2. Similar to the tool magazine on a machining centre, Werth tool measuring machines have a wide selection of sensors, such as the Werth Fibre Probe, to precisely measurable micro-geometries.

In micromachining, even the slightest deviations can disturb the process and drive up costs. Sensitive and expensive tools must, therefore, meet extremely tight requirements. To monitor quality, high precision optical or multisensor measuring machines can be used. By Christopher Morcom.

Many operators and manufacturers shake their heads when form cutter tolerances of ± 2 µm or runouts of less than 2 µm are required. It is these precise and expensive mills, however, that allow great savings in mold construction. This is because high speed cutter (HSC) technology, using high performance mills, allows one-pass machining of the finished mold (Fig. 1). When the substrate, geometry and coating are right, then modern micromills can directly machine hardened steel. This avoids the production of very complex electrodes and the slow erosion process. The surface quality, dimensions and form accuracy, however, must be nearly perfect. Therefore, the requirements placed on the mills are very high.

Figure 1. Complete machining, using HSC high performance mills to obtain the final shape, is possible only with form cutter tolerances of ±2 µm and runout of less than 2 µm. Image: Zecha

For such mills, some parameters are particularly critical for a perfect cut. The precision of the shaft has a great influence on the quality of the cut, because the grinders use the shaft as a guide during grinding. The runout of the shank is also particularly important for preventing vibrations, because the miniature mills are run in the range from 20,000 to 60,000 rpm.

Cutting depths of 20 to 50 µm are typical in final

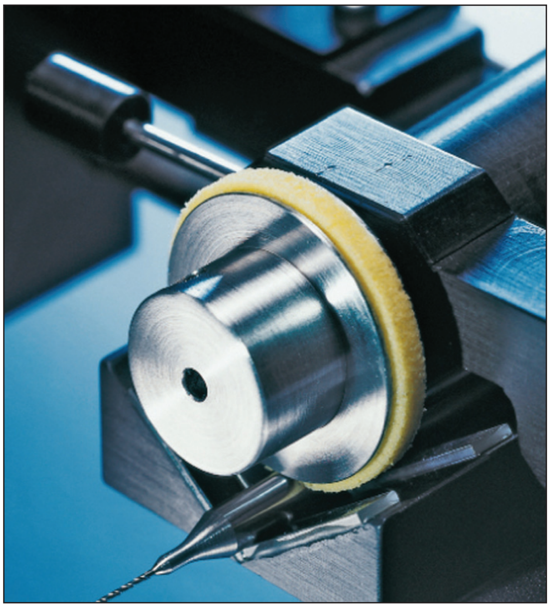

Figure 3. The special tool mount, in a sapphire-lined V-groove, allows measurement without pendulum errors.

Figure 4. NanoMatic: fast, simple, precise measurement of tools, directly in the production environment

machining. Cutting tool radii tolerances of 5 µm and lower are therefore necessary to keep all the cutting edges equally engaged. These tight radii tolerances greatly affect surface quality and eliminate costly intensive manual reworking. This also greatly increases the usable life of the mold.

To obtain these advantages, the mills must be of the best quality. Everything must be right; the substrate, the macro geometry (shank and neck shape), the shape and the quality of the cutting edges. The required quality can be assured only by combining high end grinding technology with high precision, simple measurement technology. The ability to monitor shape integrity, runout, edge quality and surface quality of the cutting and primary surfaces is the deciding factor. Tool MT GmbH provides solutions in this area.

Tool metrology

Since 2009, MT Microtool GmbH and Werth Messtechnik GmbH have joined forces in their activities in tool metrology under the name Tool MT GmbH. The cooperation provides new machine solutions for high precision measurement of tools up to 300 mm in diameter, including application specific sensors, such as image processing, lasers, or touch and scanning probes, with repeatability of less than 1 µm and compliance with VDI-VDE 2617 and ISO10360 specifications. All measuring machines are traceable to the length standard of the Physikalisch-Technische Bundesanstalt (PTB - National Metrology Institute). Therefore, the measurement results are absolutely reliable.

Well known manufacturers in the tooling industry use these systems in over a hundred installations, including Sandvik, Kennametal, HAM, Hitachi, OSG, Walter, Krupp Widia, Seco, Nachi, Wolf and Zecha. The products of these manufacturers include; indexable cutters, drills, mills, threading tools, medical and dental tools. All tools

Figure 5. VideoCheck V-HA: Tool measurements at resolutions of 10 nm and length measurement deviation less than 0.25 μm

are subjected to strict quality control and all relevant dimensions are documented.

To reliably ensure precision, high end measurement systems and non-contact processes are required. High magnification levels are required to measure diameters and small radii at a precision of less than 1 μm.

The critical factors for the performance of microtools are; form accuracy, runout, dimensional accuracy of the cutting and relief angles, and the coating used. Form and runout measurements have been performed for several years using the transmitted light scanning method. Tool MT relies on the experience with microscopy, illumination, image processing algorithms and sensors from Werth Messtechnik in Giessen (Figure 2).

Tight shape tolerances can be inspected only by means of the best tool holding technology. Classical chucks are often not precise enough. Because their runout is too big, they cause pendulum errors. The tools can be rotated for accurate runout in a precise, sapphire lined V-groove with a motor drive (Figure 3). The captured shape of the mill does not include any chucking error, it only shows only errors in the cutting edges of the tool or in the shank.

To adapt to the precision and tool size, the image processing optics are equipped with automatic magnification and working distance adjustments. They can measure the smallest details reliably, even for microtools. In addition to optics, laser and fibre probes are also used for measuring microtools. The fibre probe, with a probe sphere as small as 20 μm, is particularly useful for measuring drop-off and thread profiles on small taps or implants.

Only high precision 3D sensors make it possible to set up a control loop with the grinder to manufacture the cutting and relief angles to tolerance of ± 1° in a reliable process. The highest quality standards are a prerequisite for success against the background of globalization and rising costs, particularly for German and European tool manufacturers. To gain a time advantage in the production process, it is critical that the geometry data (2D or 3D) that are entered in the grinder software can also be used directly for automatic measurement. Data transfer takes place, for example, via a Numroto, Rollomatic, or Anca interface. The features to be measured can be selected graphically. This measurement software can be used both in machines in the production environment (ScopeCheck and NanoMatic) and in the high end measuring machines (VideoCheck HA) (Figures 4 and 5).

The measurement results are fed back into the grinder programming software and are available for automatic process correction.

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